UNSW THE UNIVERSITY OF NEW SOUTH WALES • SYDNEY • AUSTRALIA

Conference on Australian Energy Reform
Duxton Hotel, Melbourne, 29/6/04-1/7/04

Global trends in electricity markets

Hugh Outhred

School of Electrical Engineering and Telecommunications

The University of New South Wales

Sydney, Australia

Tel: +61 2 9385 4035; Fax: +61 2 9385 5993;
Email: h.outhred@unsw.edu.au

www.sergo.ee.unsw.edu.au

Outline

- Basic principle of electricity market design
- Market design types - net or gross pool
- UK: experience with NETA
- USA: California & East Coast blackout
- Implications of gas-based electricity gen'n
- Future challenges for Australian electricity & gas markets

Features of the electricity industry

- Consists of a *supply side* & a *demand side, both* with characteristics of *infrastructure:*
  - Electricity supply industry (traditional monopoly)
    - Provides (imperfect) availability & quality of supply
  - End-use equipment & user premises (private)
    - Operates according to end-user requirements
- Provides continuous *energy conversion*:
  - From primary to end-use energy forms
  - To deliver *essential (end-use) energy services*
    - Valued more by their absence than their presence

Challenges of electricity industry operation & planning

- Continuous energy flow is infused with risk:
  - Can't cost-effectively store electrical energy
- Temporal risks to energy service delivery:
  - Very short term to very long term
- Location risks to energy service delivery:
  - Network constraints can restrict energy flow
- Techniques to manage risk:
  - Physical aggregation of uncertainties by network
  - Industry decision making
    - Collective & individual, supply industry & end-users

Objectives & challenges of electricity industry restructuring

- Desirable objectives - to enhance:
  - Economic efficiency, social accountability & environmental sustainability
    - By decentralised (competitive) decision making
- Accountability challenges:
  - Shared, essential nature of network services
  - Collective (supply & demand) responsibility for availability & quality of supply
  - *Expose decision maker to associated risk*

Five perspectives on accountability of an agency (Hodge et al, 2004, p 200)

Parliamentary control	Accountable to a Minister
Managerialism	External control strategic rather than detailed
Judicial & quasi-judicial review	Formal, reviewable decision-making
Constituency relationships	Public hearings; advisory bodies; ombudsmen
Market processes	Requires meaningful consumer choice

Decision-making & risk allocation in the electricity industry

- Some centralised decision-making inevitable:
  - Instantaneous & continuous energy flow
  - Network, generation & end-use services hard to separate
- Some decentralised decision-making inevitable:
  - Demand-side of the industry privately owned
- Centralised risk allocation to:
  - System & market operators, NSPs, regulators, politicians
- Decentralised risk allocation to:
  - Generators, retailers & **end-users**
- *Difficulties arise because decisions & risks interact:*
  - *Bilateral contracts cannot manage shared risks well*

The electricity industry restructuring process

Issue	**Transition**	**Key challenges**
Industry structure	*From* monopoly *To* competing firms	Cultural change; Adequate competition; *Accountability*
Commercial framework	*From* cost recovery *To* market prices	Market power; Market design fidelity; *Accountability*
Industry regulation	*From* rate of return *To* Incentive Reg'n	Multiple objectives; Measuring outcomes; *Accountability*
Sustainability	*From* direct cost *To* full costs	Variable RE energy flows End-user participation; *Accountability*

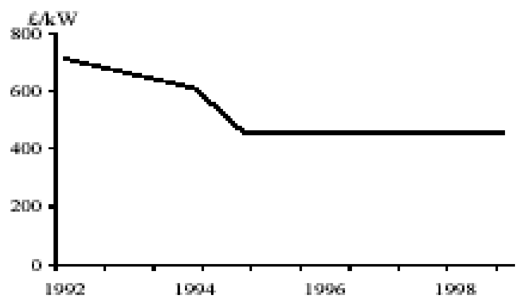
Electricity market models

- Gross pool (eg NEM):
  - Temporal & location risk managed collectively:
    - Ancillary services, spot market, PASA, SOO
- Net pool (eg UK NETA):
  - Long term & location risk managed bilaterally
    - Network not modelled in trading arrangements
  - Short-term operational risk managed collectively:
    - System operator given only one day's notice of bilateral trades

Perceived problems with the UK pool

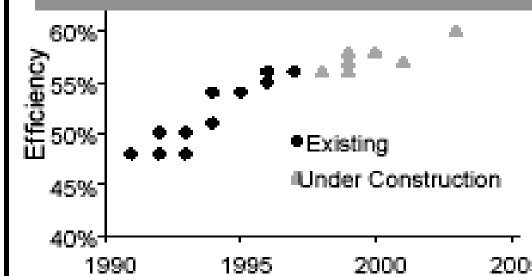
(E Marshall, England & Wales wholesale market 2 years on, Ofgem, 2003)

Capital costs fell



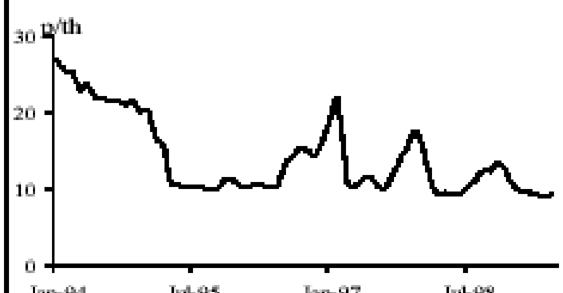
Capital costs of new plant fell by nearly 40% between 1992 and 1998

Efficiency Improved



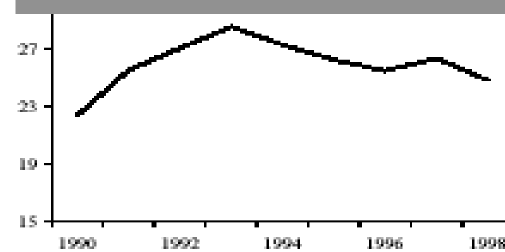
New CCGT efficiency increased by over 10% from 1990

Fuel costs fell



Spot gas prices fell by 50% between 1994 and 1998

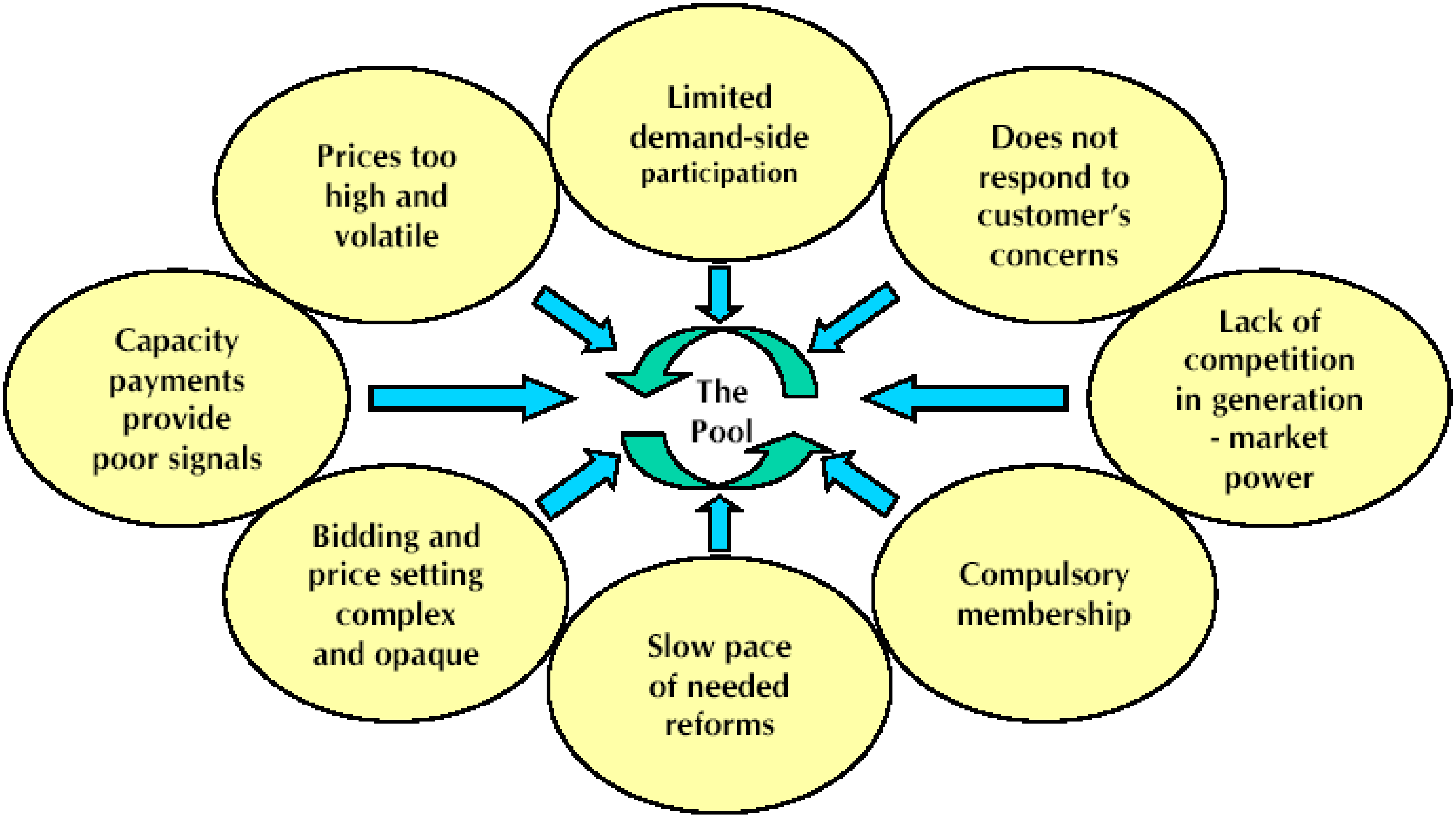
But Pool Prices didn't



Pool Purchase Price rose by over 10 % from 1990 levels.

Perceived problems with the UK Pool

(E Marshall, England & Wales wholesale market 2 years on, Ofgem, 2003)



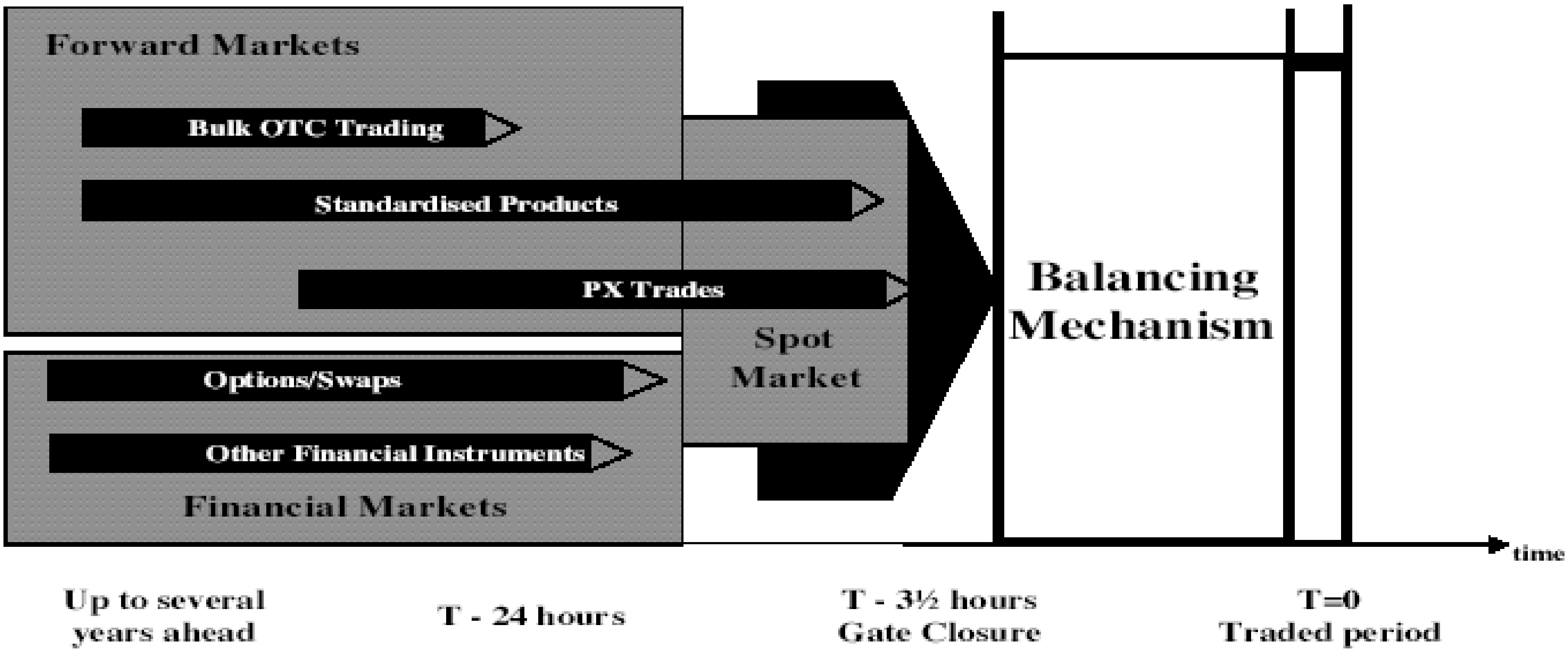
Marshall regarded these problems as fixable but easier to introduce NETA instead.

Key features of NETA

(www.ofgem.gov.uk)

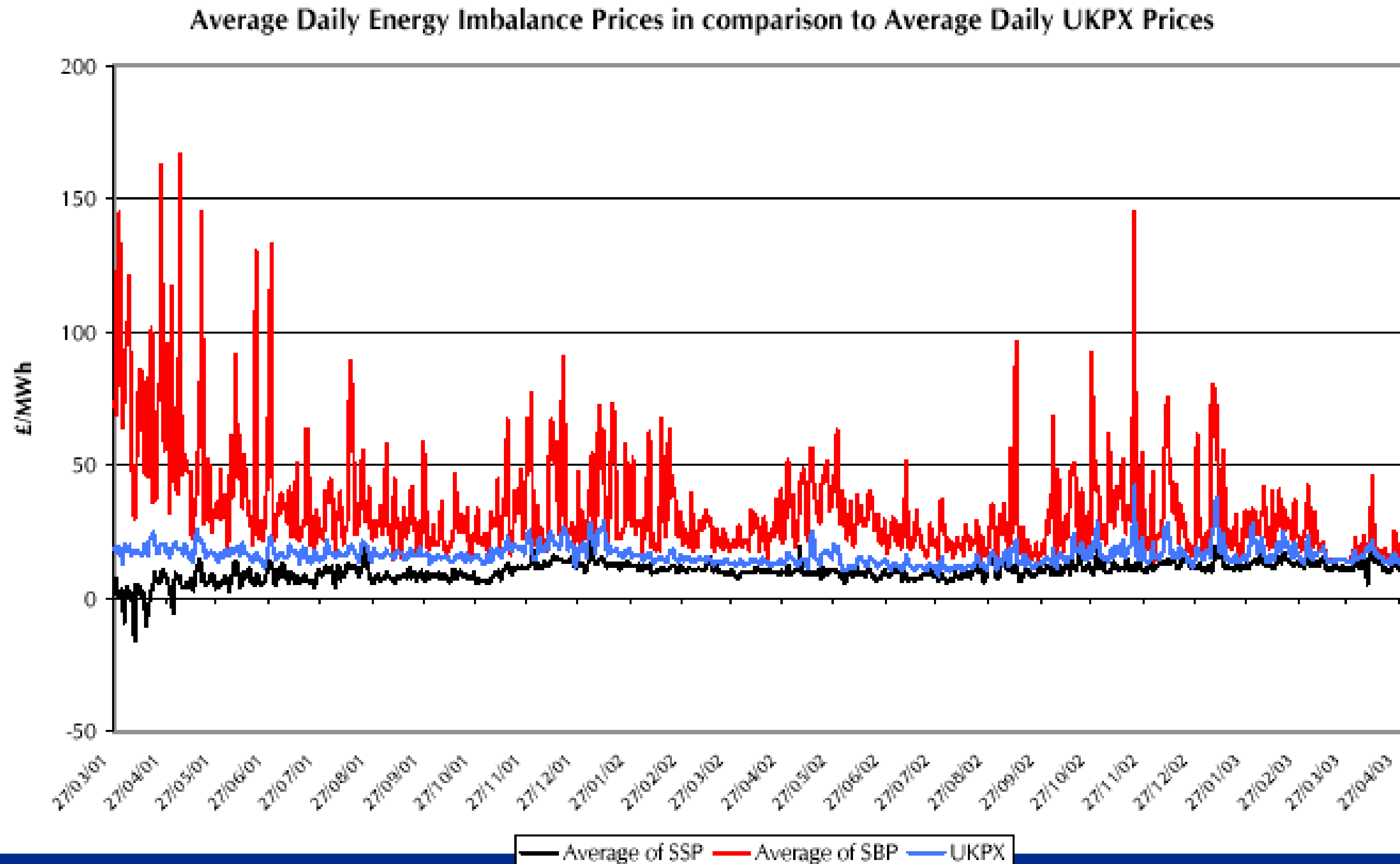
- Bilateral forward trading:
  - Compulsory notification of contract position to System Operator (NGC) by “Gate Closure”:
    - Initially 3.5 hour then 1 hour ahead from 2/7/02
- Voluntary offers to provide balancing services
- Settlement process for mismatches:
  - Under contracted generators & over contracted retailers receive “system sell” price (SSP)
  - Over contracted generators & under contracted retailers pay “system buy” price (SBP)
    - Normally expect that SBP > SSP

Key features of NETA
(Ofgem 1 year review of NETA, July 2002)



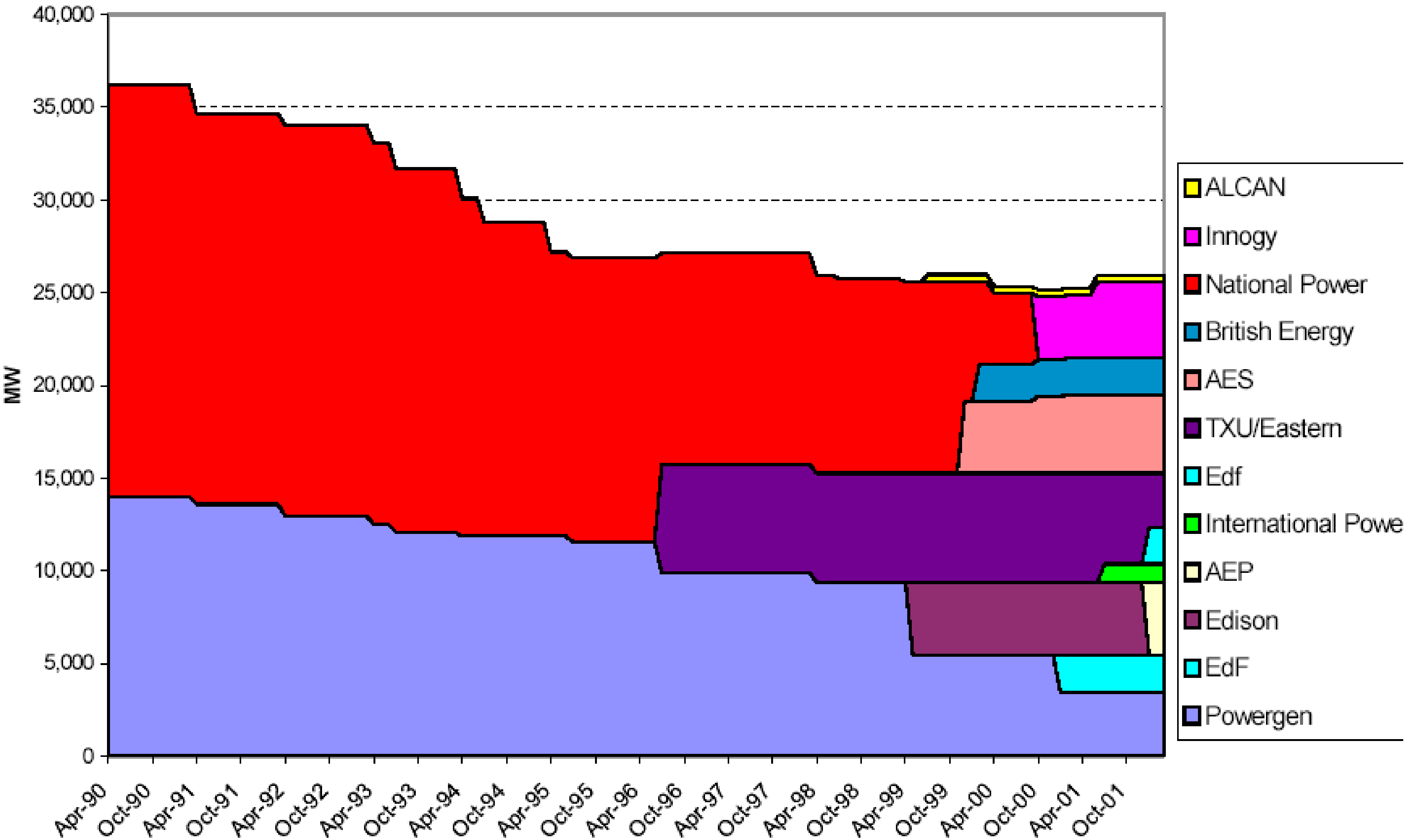
Daily average system buy & sell balancing prices and current day forward price (UKPX)

(S Brown, England & Wales wholesale market 2 years on, Ofgem, 2003)



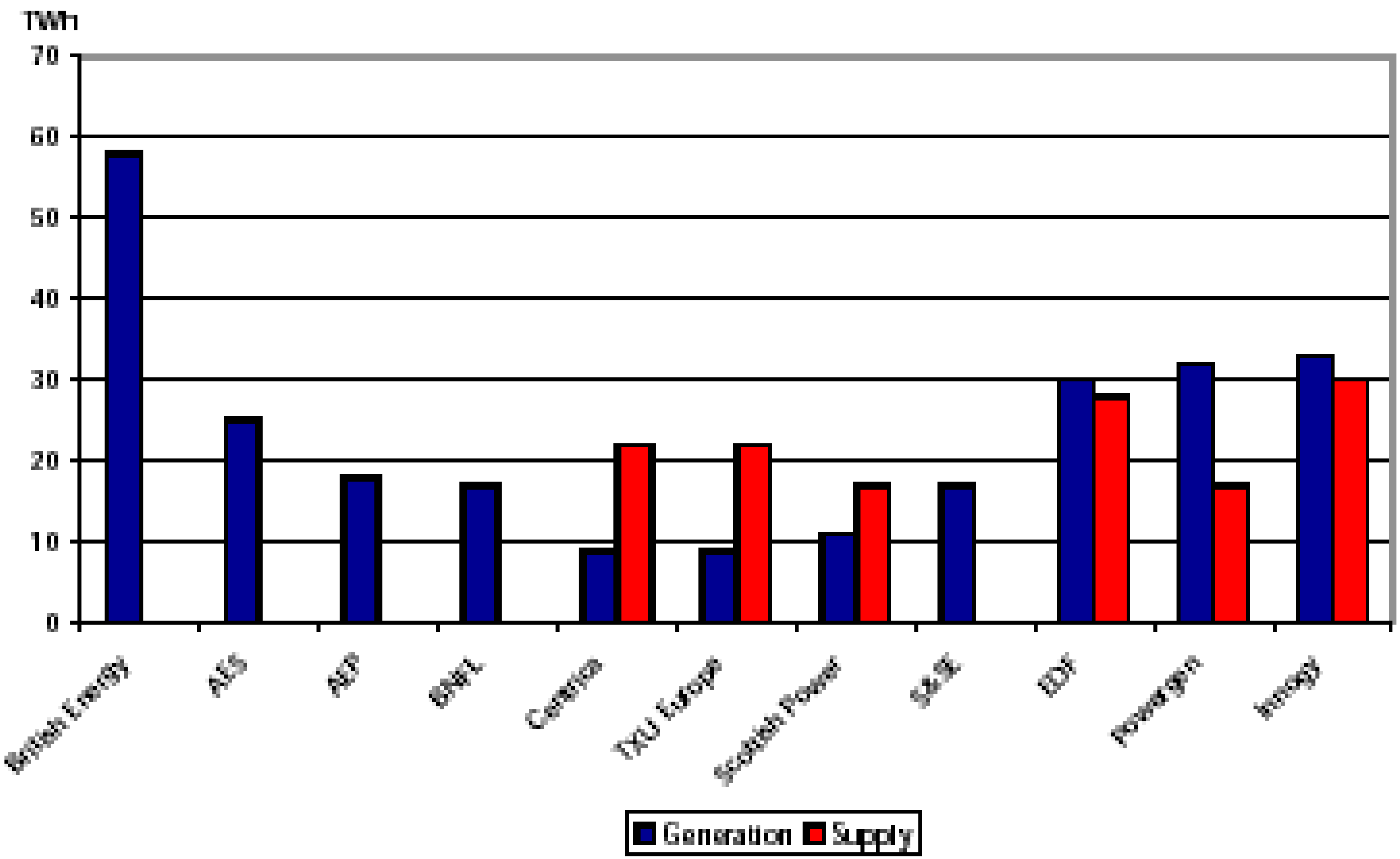
Ownership of UK coal-fired generation 1990-2001

(D Newbery, England & Wales wholesale market 2 years on, Ofgem, 2003)



Trend towards vertical integration reduces reliance on balancing mechanism

(Ofgem 1 year review of NETA, July 2002)

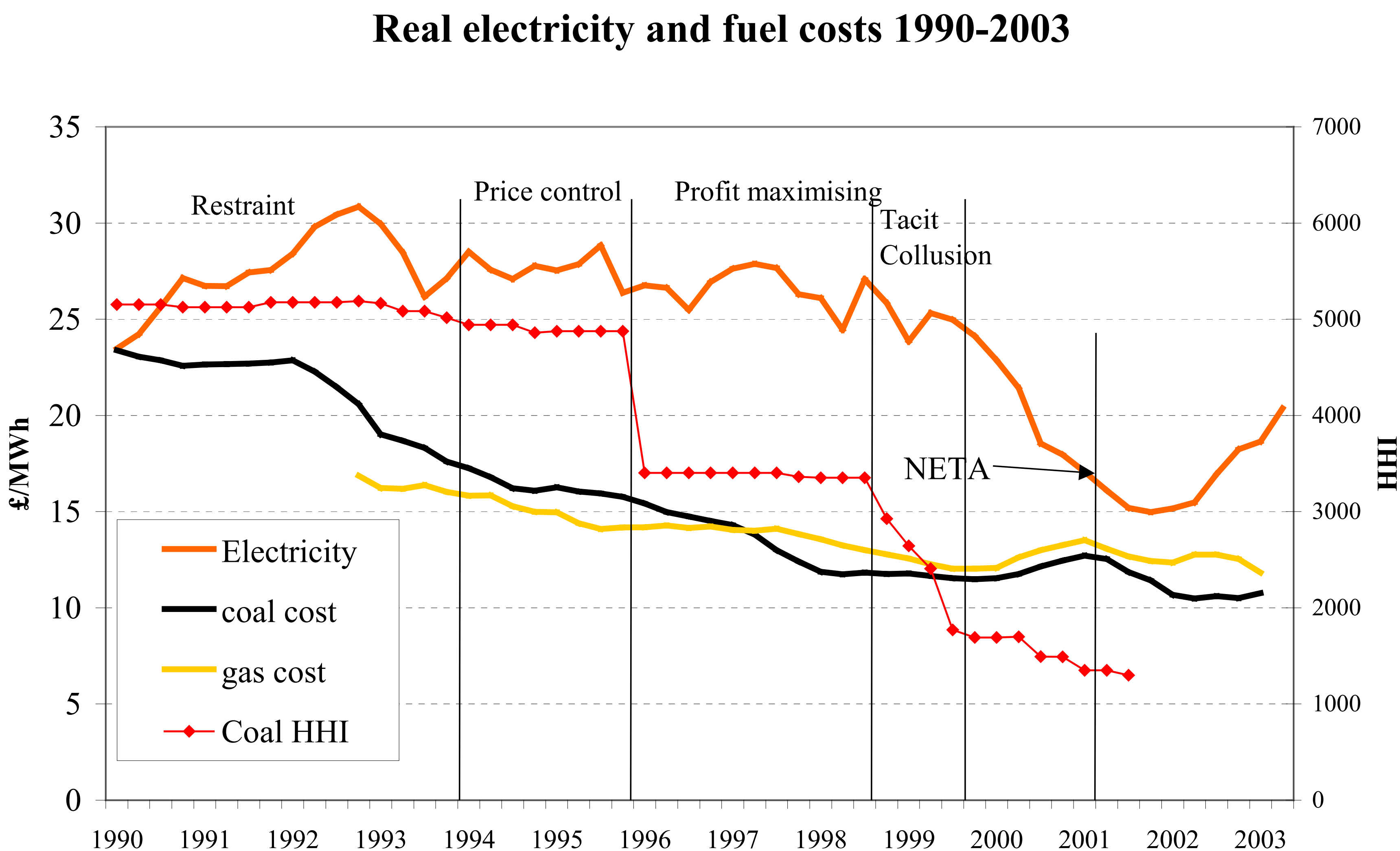


Some UK perspectives on NETA

(D Newbery, England & Wales wholesale market 2 years on, Ofgem, 2003)

- Newbery (Cambridge University):
  - Increased competition in fuel & generation may be the key driver on wholesale price reductions
  - NETA very expensive to implement
- Yarrow (Oxford University):
  - How will security of supply be maintained?
  - Demand side more clearly involved
  - Transmission losses & constraints difficult under NETA

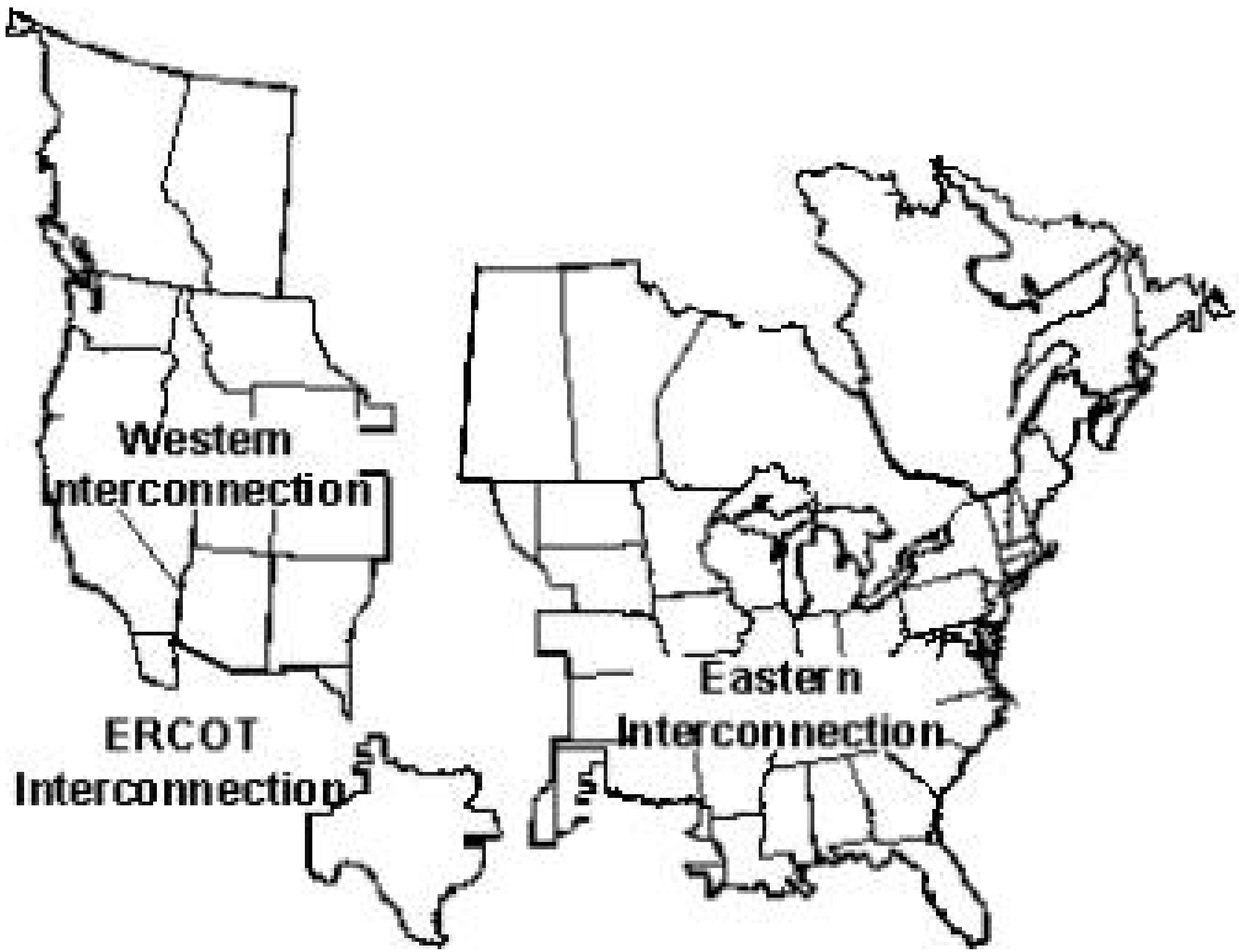
Reduction in electricity prices "not due to NETA" (Mirrless-Black, IEE Ireland colloquium, 2004)



Some Australian perspectives on NETA

- COAG energy market review final report:
  - NETA's requirement for individual balancing:
    - "a significant inefficiency that adds cost to the system"
  - Gross pools have advantages over net pools:
    - Encourage generators to supply at marginal cost
    - Reduce barriers to entry
    - Transparent data supports informed decisions
- ACCC:
  - Market power not reduced by moving to net pool
- Outhred:
  - NETA biased against intermittent generation & distributed resources

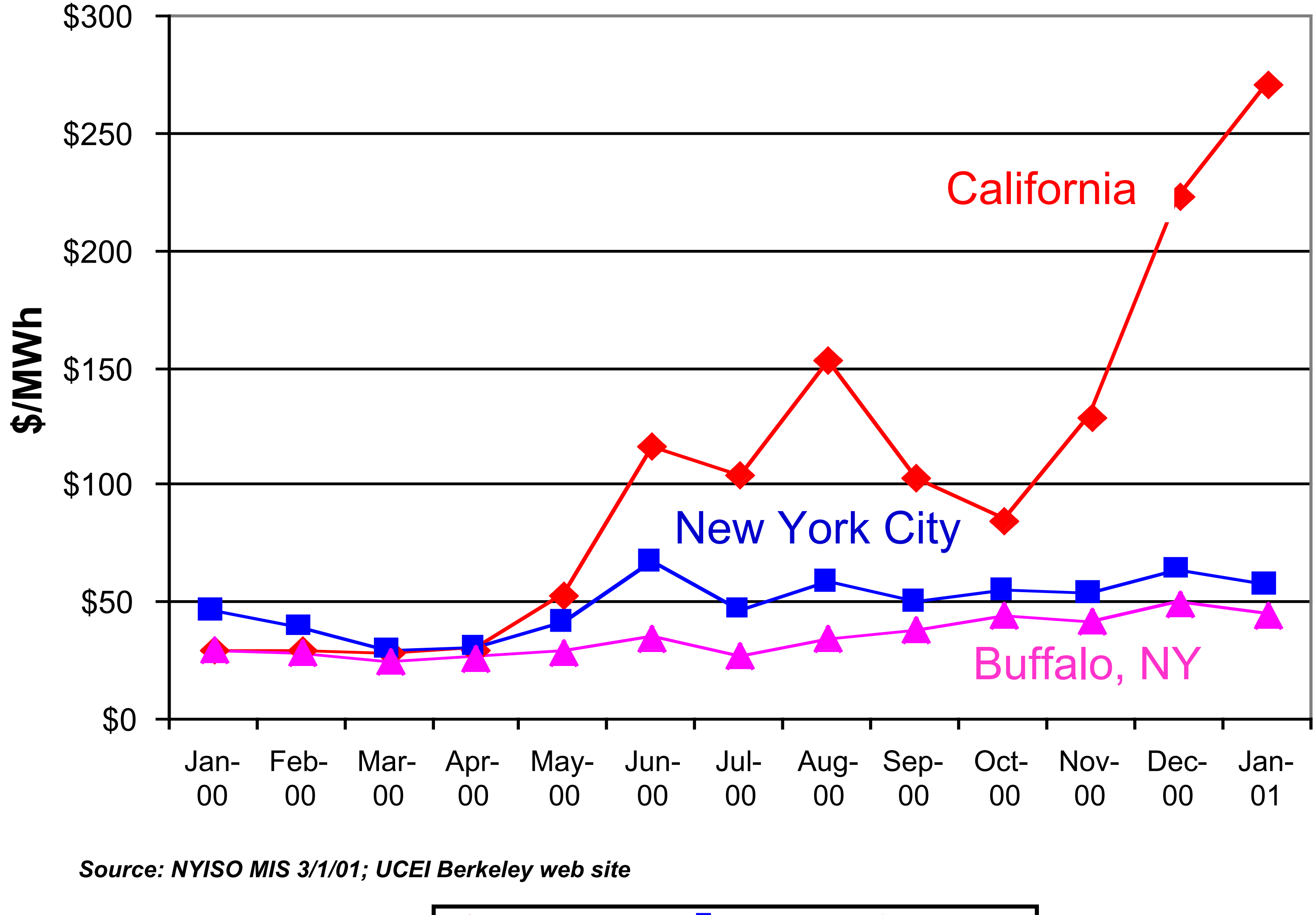
North America (USA, Canada, Mexico): Three interconnected power systems



Electricity industry restructuring in USA

- Federal level (inter-state trade):
  - PURPA (1978) required utilities to buy from "qualifying facilities" within their service territories
  - EPA (1992) mandated transmission access for wholesale transactions (buyers must be utilities):
    - Access & "wheeling" charges (a bilateral trade model) regulated by Federal Energy Regulatory Commission
- State level (intra-state trade):
  - Some states began EI restructuring:
    - Bilateral trade (eg California) or pool (eg PJM)
    - Single state (California) or groups of states (PJM)

Comparison of day-ahead average electricity prices in California & New York for 2000 (Flaim, 2003)



Source: NYISO MIS 3/1/01; UCEI Berkeley web site

Comments on California restructuring

- A politically influenced bilateral trading model:
  - Compromises, inconsistencies & complexity
- Many non-ideal features:
  - Not consistent across Western System:
    - Or even within California
  - Economic & technical regulation separated
  - No coordinated support for investment decisions:
    - eg IOUs were forbidden to forward contract
  - Poor spot market design (CalSO default market)
  - Short horizon for managing system operation
  - Large residual task for ancillary services

Other contributing factors

- Hydro reserves had been run down:
  - California still ~25% hydro energy
- Gas & NOx permit prices were rising:
  - Allegations of market power in gas market
- Approval difficult for new generation & network
- Continuing growth in demand, including:
  - Temperature sensitive residential air-conditioning
  - High-value commercial & high-tech industrial
- High wholesale prices & regulated retail tariffs:
  - PG&E and SCE eventually went bankrupt

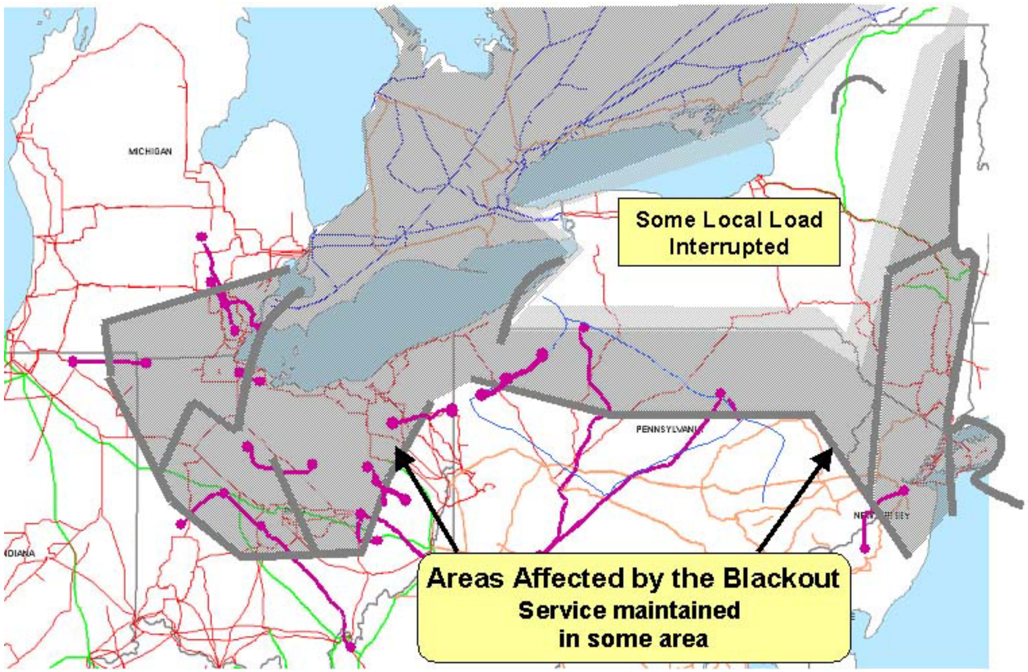
The North America Blackout of 14/8/03

(www.spectrum.ieee.org/webonly/special/aug03/black.html)

- DOE studies had predicted trouble since '98:
  - Inadequate regional oversight & control
- Operators unable to stop problem escalating :
  - Midwest ISO had less authority than PJM & New England counterparts
  - Human errors & loss of institutional capacity
- Remedies:
  - Create regional ISOs
  - Build network capacity & institutional skills

Affected areas
(T Mount, Cornell University, 2004)

When the cascade was over at 4:13pm, over 50 million people in the northeastern USA and the province of Ontario had no power.



Conclusions on blackout 1

(T Mount, Cornell University, 2004)

The blackout was NOT caused by:

- **1) An Act of God (extreme weather)**
- **2) Maliciousness (sabotage or a computer virus)**
- **3) Insubordination (supply of reactive power)**
- **4) System conditions (wheeling power)**

BUT the limited control of system operators in some regions (#3) and the long distance transfer of power (#4) increase the complexity of operating a reliable grid compared to a fully regulated system.

Conclusions on blackout 2

(T Mount, Cornell University, 2004)

The blackout was caused by:

- 1) A series of typical contingencies occurred that were not recognized or contained by First Energy (FE):
  - Initial tree strikes → POOR MAINTENANCE
  - Many lines trip → POOR MONITORING
- 2) The problem was not contained locally by FE and other system operators in the Midwest → POOR COORDINATION
- 3) Unexpected power surges caused relays to trip correctly in a cascading system collapse
- 4) Damage to transmission and generating equipment was minimal, and the system was restored effectively
- 5) The costs incurred by many customers were substantial

A hypothesis: If the industry and regulators had followed the recommendations made after the 1965 New York blackout, the latest blackout would not have happened.

Conclusions from North American experience (Massey, 2003)

- Electricity doesn't respect political boundaries
- Fundamental design principles:
  - Spot market with locational pricing signals
  - Independent grid and market operation
  - Consistent rules over entire market region
  - Firm transmission rights
  - Market monitoring and mitigation of market power
- Enlarging market scope by interconnection:
  - Reduces supply-side market power
  - Requires consistent rules & regulation

General implications for Australia

- Industry structure & market design both matter:
  - Electricity & gas consistency, barriers to entry, market power, pressure to reveal preferences
- Consistent wholesale & retail market design:
  - For ancillary service, spot & forward trading
  - Across the full scope of a transmission network
- Governance independent from participants
- Regulation essential but implement carefully:
  - Market intervention can exacerbate dysfunction & increase uncertainty

Implications of natural gas for electricity generation

- Electricity gen’n has variable demand for gas:
  - Gas pipeline network has limited storage
  - Traditional gas market model not good at rationing scarce pipeline capacity
- New gas trading arrangements will be needed:
  - The NEM provides an appropriate model for existing gas networks
  - Special arrangements may be needed to support green-fields gas infrastructure investment

Conclusions - future challenges

- Electricity:
  - Enhanced demand side participation
  - Uniform governance & regulation
  - Efficient network investment that gives equal consideration to distributed resource options
- Gas:
  - Efficient market design for existing gas network
  - Efficient investment in gas infrastructure
- Sustainability of the stationary energy sector:
  - Dramatic reduction in climate change emissions

A key challenge: investment in new generating capacity: Forecast surplus reserves for NEM Jurisdictions

(Medium growth + extreme (10% POE) weather, NEMMCO SOO, July 03)